MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

EEL4106 – HIGH VOLTAGE ENGINEERING

(LE)

24 OCTOBER 2019
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 5 pages including the cover page with 4 Questions only.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) The demand for very high DC voltages forced the improvement of rectifiers. Today, many standard cascaded circuits are available for the conversion of AC to DC voltages.

(i) List out **TWO** reasons why the Cockroft Walton voltage multiplier circuit is preferred, as compared to voltage doubler cascaded circuit. [2 marks]

(ii) Draw the 4-stage Cockroft Walton voltage multiplier circuit, and label the diode, D and capacitor, C with the correct stage numbering. [5 marks]

(b) Resonance transformer has been found to have many advantages. A 150 kVA 400 V/300 kV feed transformer has resistance and reactance of 2% and 4%, respectively. This transformer is used to test a cable at 300 kV at 50 Hz. The cable takes a charging current of 0.6A at 300 kV.

(i) Determine the series inductance required. [5 marks]

(ii) Assume 3% resistance of the inductor. Determine the input voltage to the transformer. Neglect dielectric loss of the cable. [4 marks]

(c) In 1923, E. Marx suggested a multistage impulse circuit using identical capacitors charged in parallel and discharged in series. List out **FOUR** reasons why the single stage circuit is inconvenient to be used to generate for high voltages. [4 marks]

(d) An impulse generator has eight stages with each capacitor rated for 0.16 μF and 125 kV. The load capacitor available is 1000 pF. Find the series resistance needed to produce the standard front time of impulse voltage. [5 marks]

Question 2

(a) Sphere gap is one of the standard methods for the measurement of peak value of DC, AC and impulse voltages. State **THREE** factors that influence a sphere gap for the measurements of the peak value of voltages. [6 marks]

(b) Measurements of high voltages are the basis for testing high voltage equipment. The measurement techniques should prevent flashover and heat dissipation within the measuring circuits. (It should not be a load on the system whose parameters to be measured.) There are three types of voltages to be measured, namely DC voltage, AC voltage and impulse voltage. Complete Table Q2(b). [8 marks]

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Table Q2(b)

System/device	Type of voltage measured	Main advantages	Main drawbacks
Sphere gaps	AC, DC and impulse	Simple, reliable, cheap	
Electrostatic voltmeter	AC, DC	Extremely high input impedance, very accurate	
Peak voltmeter	AC		There are many sources of error (frequency, capacitors, diodes, LV meters)
Resistive divider, a cable and LV meter or an oscilloscope	AC, DC and impulse		The presence of stray capacitance especially for EHV and UHV dividers and fast transients

(c) The resistive dividers are preferred for the measurement of steep impulse voltage of not too long a duration. For voltage more than 1 MV, the resistance is made of a large number of sections. In such cases, the ground capacitance C_g current in the resistances of resistive divider will be present and varying. Briefly describe what happen to the voltage distribution along the length of the resistors with the presence of C_g, and how it can be compensated. [3 marks]

(d) The purpose of the high voltage testing is to ensure that the electrical equipments are capable of withstanding the overvoltages, that are met within service. There are three standard tests carried out on the equipments, namely routine, type and special tests. Briefly describe the type test, and provide one example of the type test. [3 marks]

(e) Failure in a transformer can be known from high voltage impulse tests. Sketch three impulse voltage traces indicating the applied voltage, no failure and failure on the transformer. [5 marks]

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Question 3

(a) There are several factors affecting the dielectric strength of liquid dielectrics, namely temperature, moisture, time lag and frequency. It is known that dielectric loss is directly proportional to the frequency of supply where permittivity of liquid dielectric is inversely proportional to the frequency. Briefly describe how temperature and moisture would affect the dielectric strength of liquid dielectrics. [4 marks]

(b) Various theories have been proposed for the breakdown in liquids, such as: suspended particle theory, cavitation and bubble theory and stressed oil volume theory. A common factor responsible for breakdown of liquid is the formation of cavity and bubbles in liquids. Two common processes have been suggested to be responsible for the formation of the vapour bubbles; gaseous products due to the dissociation of liquid molecules by electron collisions and vaporisation of the liquid by corona type discharge from sharp points and irregularities on the electrode surfaces. List out **TWO** other common processes to be responsible for the formation of the vapour bubbles. [4 marks]

(c) Two of the factors affecting the breakdown in solid dielectrics are: mechanical strength and temperature. List out other **TWO** factors affecting the breakdown in solid dielectric. [2 marks]

(d) When a solid dielectric is subjected to electric field stress, E, the material gets heated up and dielectric losses due to polarization. On the same graph, plot **THREE** heating curves (Heat Gain/Loss vs. Specimen Temperature) for three different electric field stresses, where $E_1 \angle E_2 \angle E_3$ [5 marks]

(e) A solid insulating block of thickness 2.5 cm and having a dielectric constant of 4 is subjected to a 50-Hz AC voltage. The specimen contains an air void of thickness 1.0 mm. Considering the breakdown strength of air as 30 kV/cm (peak), find the maximum voltage which can be applied across the specimen without any internal discharge. [5 marks]

(f) A steady current of 1000 μA flows through a gas between two plane electrodes separated by a distance of 0.4 cm when an AC voltage of 8 kV is applied. Determine the Townsend's first ionization coefficient if a current of 100 μA flows when the distance of separation is reduced to 0.3 cm and the field is kept constant at the previous value. [5 marks]

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Question 4

(a) On different impulse voltages applied, breakdown will occur and the time lag will depend on the rate of rise of the applied voltage and the field geometry.

(i) Plot the typical voltage trace during breakdown, indicating the statistical and formative time lags. [2 marks]

(ii) Briefly define the statistical and formative time lags. [3 marks]

(b) Time lags curve for the protection devices of rod gap 1, rod gap 2 and surge diverter for the protection of a transformer is shown in Fig. Q4(b). Line *X* is the critical slope line. Illustrate the safety margin between the transformer and all three protective devices. [6 marks]

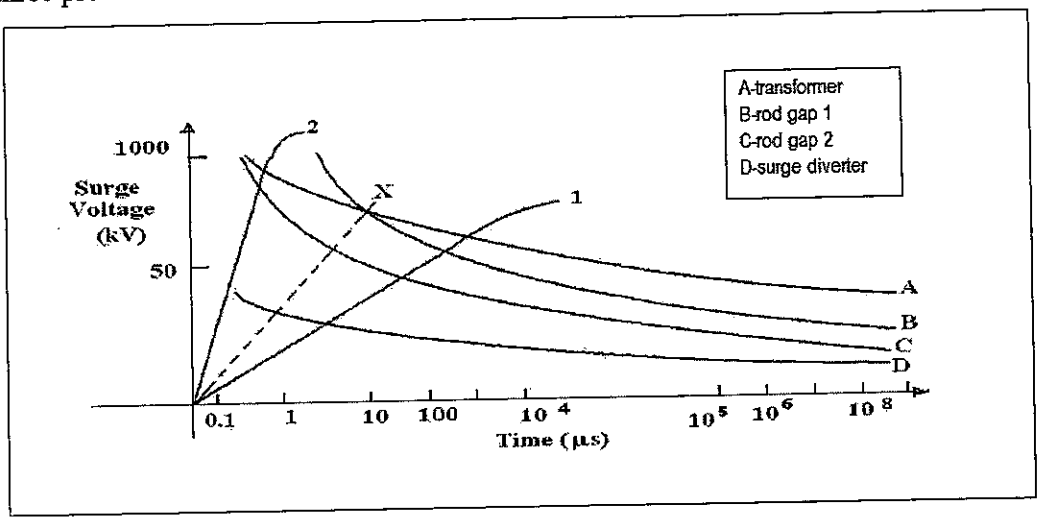

Fig. Q4(b)

(c) In order to protect the equipment from overvoltage, protective devices are used. These devices are essentially shunt devices across equipment insulation and are used to keep the voltage across the insulation to an acceptable level by allowing a bypass to the surge to earth.

(i) List out **FOUR** functions and requirements of surge diverters. [8 marks]

(ii) List out **TWO** advantages and **TWO** disadvantages of this rod gap (horn gap). [6 marks]

End of Paper.